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MINERAL RESOURCE ASSESSMENT THROUGH GEOCHEMICAL STUDIES OF HEAVY MINERAL CONCENTRATES FROM WILDERNESS STUDY AREAS IN THE BURNS, PRINEVILLE, AND VALE DISTRICTS, SOUTHEASTERN OREGON

Prepared By:

J. F. Bukofski
J. S. Lovell
W. T. Meyer

Barringer Resources Inc.
1626 Cole Boulevard
Golden, Colorado 80401

Prepared For:

United States Department of the Interior
Bureau of Land Management
Oregon State Office
825 N. E. Multnomah, Portland, Oregon 97208

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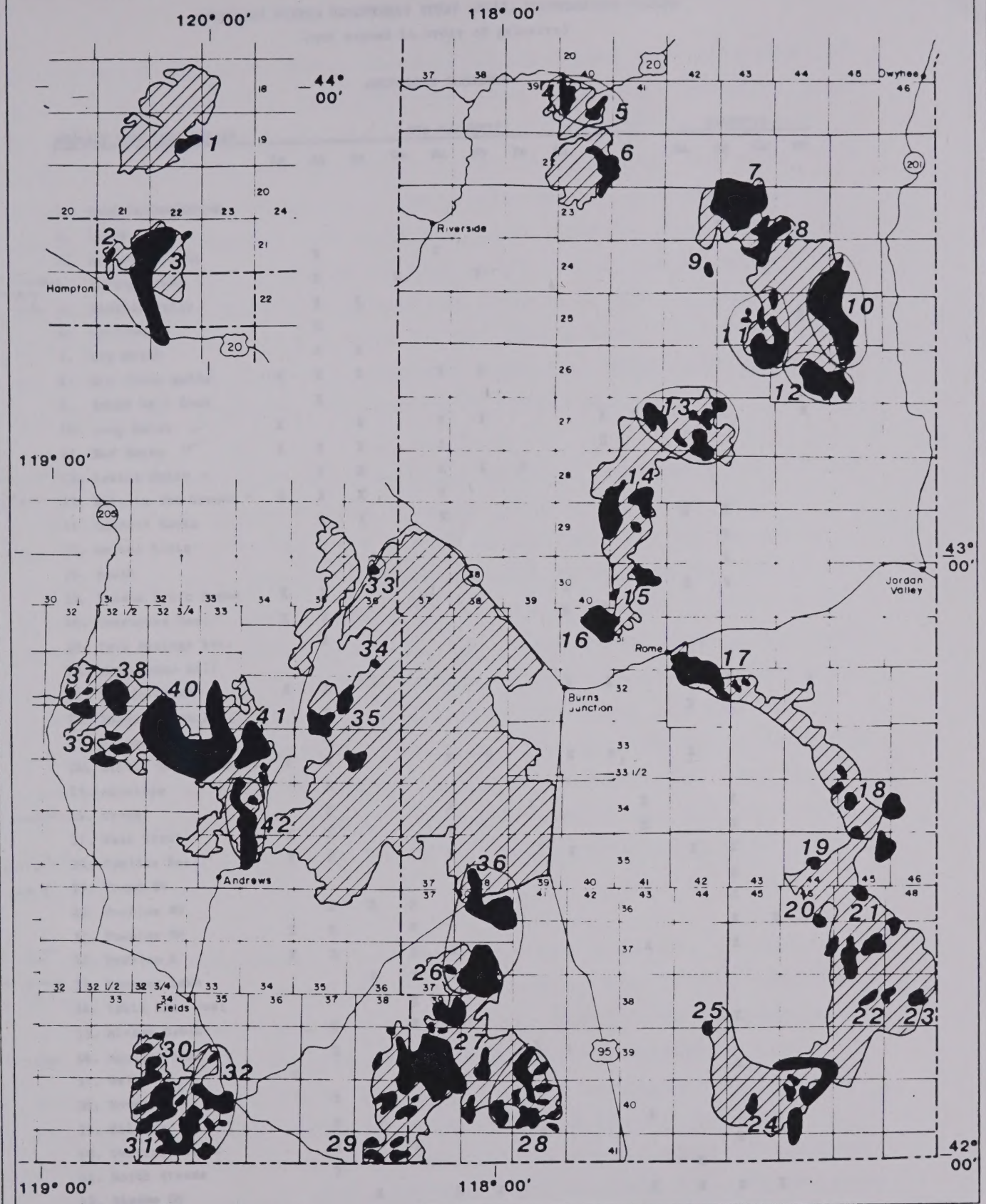
EXECUTIVE SUMMARY

Barringer Resources Inc. has undertaken a geochemical-mineralogical study of heavy mineral concentrates collected from approximately 1,250 sites located in southeastern Oregon for the Bureau of Land Management. The primary objective of this study was to provide interpretive information concerning metallic mineral potential of thirty-seven Wilderness Study Areas. These data are to be used by the BLM to supplement existing Geology-Energy-Mineral (GEM) resource data thought to be inadequate by BLM geologists for multiple-use decisions concerning the Wilderness Study Areas. An integrated geological, mineralogical, and geochemical approach was used.

The study region of about 1.1 million acres is divided into ten separate study areas each containing more than one Wilderness Study Area. 1,163 samples had been collected from six areas and a portion of a seventh comprising about 1,250 square miles while the remainder (99) were taken from three areas and a portion of a fourth that encompass roughly 500 square miles. Geochemical data generated from analysis for up to fourteen elements were statistically processed and plotted as symbol maps for each area. Interpretation of the data was completed using available geologic information, lithochemistry and geochemical principles, and data from previous -80 mesh stream sediment studies.

Forty-two anomalies (Figure 1, Table 1) were identified that contain from one to six anomalous elements and range in size from single samples to fifty-seven samples. The metallic mineral potential for each of these anomalies ranges from poor to very good for both base and precious metals. Follow-up programs of detailed stream sediment sampling, or ridge and spur soil sampling combined with detailed geologic mapping are recommended for thirteen of the anomalies.



ANOMALIES WITHIN WILDERNESS STUDY AREAS, SOUTHEASTERN OREGON

BARRINGER RESOURCES

Figure 1

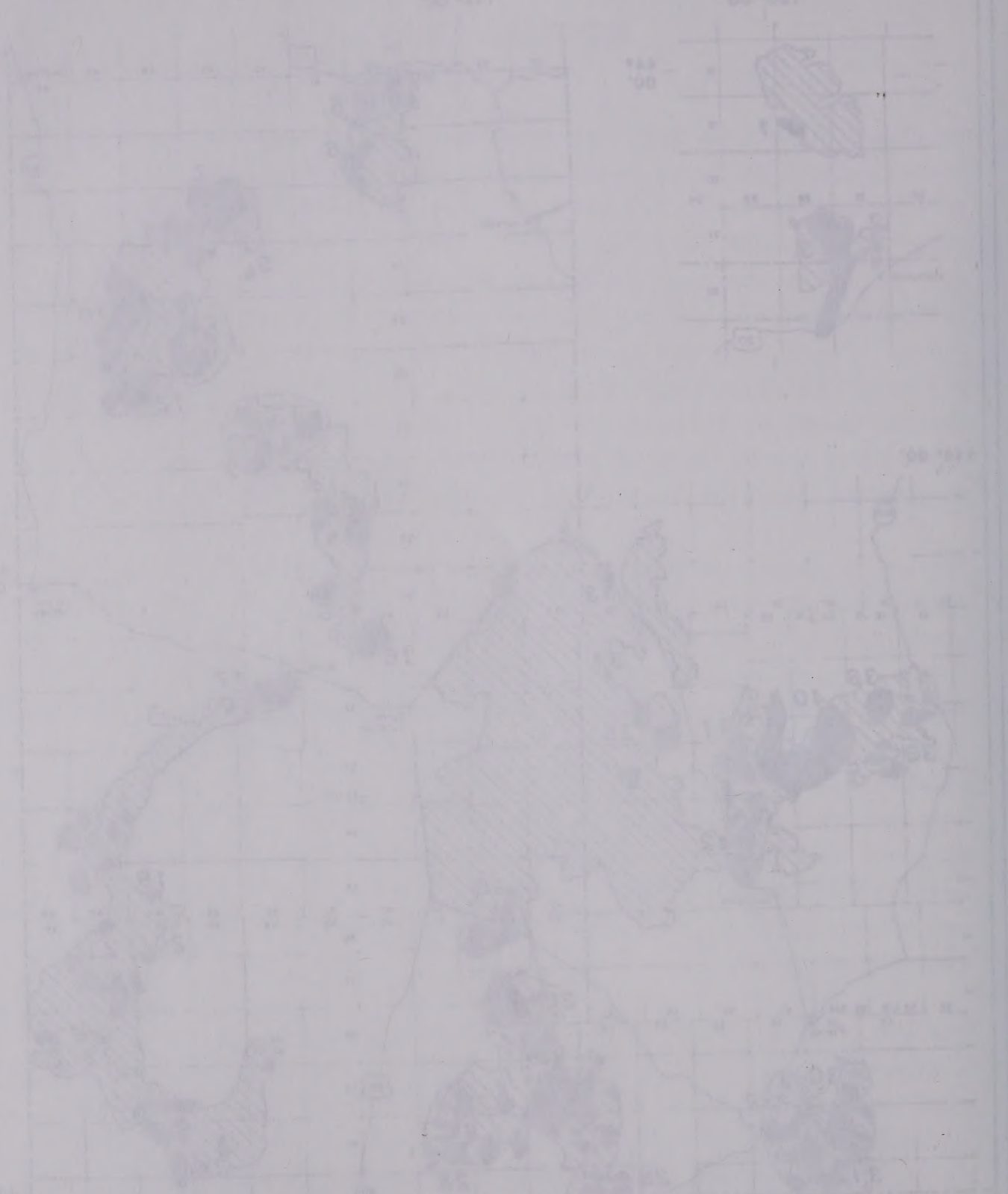


Table 1.

ANOMALIES WITHIN WILDERNESS STUDY AREAS, SOUTHEASTERN OREGON

(not ranked in order of priority)

ANOMALY NAME AND NUMBER	ANOMALOUS ELEMENTS													
	NON-MAGNETIC										MAGNETIC			
	Au	Ag	As	Cu	Mo	Pb	Zn	Sn	F	W	Au	Ag	Cu	Mo
1. Sand Hollow Creek												X		
2. Crook												X		
3. Seamon's Place		X			X									
4. Spring Creek		X		X		X								
5. Simmons Gulch		X	X											
6. Cottonwood		X												X
7. Dry Creek		X	X											
8. Dry Creek Butte	X	X	X		X	X								
9. South Wall Rock		X												
10. Long Gulch	X		X		X	X			X	X		X		X
11. Red Butte	X	X	X		X				X					
12. Leslie Gulch		X	X		X	X	X							
13. Hole in the Ground	X	X	X		X									
14. Lambert Rocks		X	X		X						X	X		
15. Owyhee Butte												X		
16. South												X		
17. Poison Drift Fence	X	X						X			X	X		
18. Porcupine Res.	X	X						X	X					
19. Twin Springs Res.		X												
20. Sacramento Hill												X		
21. Toppin Creek	X	X						X	X			X		X
22. Toppin Creek Res.		X									X			
23. Oregon		X												
24. Little Owyhee Canyon	X	X			X	X		X	X		X			
25. Antelope		X												
26. Creek		X			X		X			X		X		
27. West Trout	X	X			X					X		X		
28. Opalite Res.	X	X			X			X			X	X		
29. Trout SW												X		
30. Pueblos NW		X	X	X								X		
31. Pueblos SW	X	X		X								X	X	
32. Pueblos E	X	X		X	X					X		X		
33. Tencent Lake			X	X	X	X								
34. Table Mtn. West				X										
35. Mickey Cabin		X		X								X		
36. Ancient Lake		X					X							
37. Well	X											X		
38. Donner		X												
39. Blitzen		X								X				
40. Central Steens		X		X								X		
41. North Steens		X									X			
42. Steens SE			X		X	X				X	X	X	X	

Correlation between heavy mineral concentrate analysis and -80 mesh stream sediment analysis was good for gold, arsenic, lead, zinc, and tin, and moderate for silver. In future programs, with the possible exception of gold, analysis of -80 mesh samples may be adequate for these elements. However, the analysis of elements and minerals that tend to concentrate in the heavy mineral portion of the sample (e.g. chromium, tungsten, tin, platinum, monazite, thorite) should continue. The correlation between gold in the heavy mineral fraction and in the -80 mesh fraction suggests that the gold mineralization in the area is of the "invisible gold" type.

Mineral identification of samples prior to analysis identified two prominent associations between mineral species and anomalies. The first is a positive correlation between the presence of limonite in the sample and anomalous values. Further work is recommended to ascertain whether limonite in this area is a useful guide to the presence of mineralization. In future studies iron and manganese concentrations should be utilized to recognize spurious anomalies that are due to preferential accumulations of trace elements in oxide coatings and precipitates. The second mineral association identifies a correlation between amphibole in the sample and silver values. The amphibole appears to be principally associated with rhyolitic rocks.

The interpretation of these data and the analysis of the samples have been severely constrained by the highly variable, and in some cases grossly inadequate, quantities of sample. This is probably attributable to preconcentration of the samples in the field by panning. It is strongly recommended that this procedure should never be used in any future programs. Heavy mineral concentration should only be carried out in a laboratory where adequate and reproducible techniques are available.

INTRODUCTION

Barringer Resources Inc., on behalf of the Oregon State Office of the Bureau of Land Management, has undertaken a geochemical-mineralogical study of heavy mineral concentrates collected from approximately 1,250 sample sites located in about 1,750 square miles containing 37 Wilderness Study Areas located in southeastern Oregon. The objective of this study is to provide much needed information regarding metallic and strategic mineral potential which is to be used by the BLM in conjunction with previous mineral potential evaluations to make multiple-use decisions concerning the Wilderness Study Areas. The work plan consisted of the following seven tasks:

Task I Sample preparation which included panning of 52 samples, heavy liquid separation of 1,262 samples, and magnetic separation of 1,262 samples.

Task II Detailed mineralogical examination of 23 samples which relied on information gathered using x-ray diffraction, crystallographic properties, and Frantz Isodynamic separation. This was followed by a visual mineralogical examination of 1,262 nonmagnetic heavy mineral concentrates and 600 magnetic heavy mineral concentrates utilizing a binocular microscope routinely set at 20x magnification.

Task III Geochemical analysis of 1,262 nonmagnetic heavy mineral samples for 12 elements; determination of 4 elements for 600 magnetic heavy mineral samples; and analysis of 20 samples selected from a mafic area for 4 elements.

Task IV Data Processing which included:

1) Digitizing of sample locations and combining them with the various geochemical determinations.

2) Calculation of means, standard deviations, minima, maxima, correlation coefficients, and log-normalized values for each element of the data set.

Task V Creation of geology plates, sample location maps, and single-element maps for each of the 10 areas (Area 9 was divided into north and south halves).

Task VI Compilation of geochemical anomaly maps and interpretation of data using geology and previous stream sediment studies.

Task VII Final report preparation.

The report consists of six sections: Executive Summary, Introduction, General Geology, Geochemistry, Metallic Mineral Potential, and Conclusions and Recommendations. The maps, geochemical results, mineralogical identification results, and initial sample weights have been placed in appendices.

Acknowledgement is made to the COAR, Dr. Durga Rimal and the other personnel of the Bureau of Land Management who provided valuable information on specific areas and general background knowledge of the area.

Table 4a.
Summary Statistics - DOGAMI Nonmagnetic Fraction Samples
(data in ppm unless otherwise noted)

Element	Mean	Standard Deviation	Geometric Mean	Log Standard Deviation	Min	Max	Threshold
Au (ppb)	1.2	1.9	1.0	.024	1.	350.	2.
Ag	.01	.009	.01	.097	.01	2.28	.02
As	7.9	8.7	5.8	.326	2.5	235.	22.
Cu	22.1	21.5	14.4	.375	2.	560.	69.
Mo	.9	1.0	.7	.254	.5	49.	2.
Pb	8.2	11.9	4.7	.459	1.	1080.	32.
Zn	57.3	42.7	47.8	.284	10.	1010.	202.
Sn	5.2	5.8	2.9	.515	1.	50.	25.
F	257.	183.	206.	.314	10.	3400.	875.
W	4.1	3.8	3.1	.286	2.	120.	17.

Table 4b.
Summary Statistics - Terradata Nonmagnetic Fraction Samples
(data in ppm unless otherwise noted)

Element	Mean	Standard Deviation	Geometric Mean	Log Standard Deviation	Min	Max	Threshold
As	6.3	7.	4.3	.372	2.5	130.	29.
Cd	.51	.08	.51	.043	.5	30.5	1.0
Cu	39.5	34.	26.5	.426	3.	153.	107.
Mo	14.8	29.	2.	.913	.5	934.	109.
Pb	2.	9.2	1.	0.	1.	1100.	2.
Zn	126.	78.4	103.	.292	15.	879.	374.

Table 4c.
Summary Statistics - All Magnetic Fraction Samples
(data in ppm unless otherwise noted)

Element	Mean	Standard Deviation	Geometric Mean	Log Standard Deviation	Min	Max	Threshold
Au (ppb)	1.	.1	1.	0.	1.	6.	2.
Ag	.01	.008	.01	.111	.01	.61	.02
Cu	34.8	29.2	25.1	.389	4.	178.	105.
Mo	1.57	1.1	1.3	.317	.5	9.	5.
Cr	77.	24.2	73.	.153	27.	132.	110
Ni	54.	9.6	53.	.084	33.	68.	66.

Individual element anomalies are briefly discussed and more completely tabled below. It must be remembered that the anomalies are geochemical and geostatistical in nature and do not necessarily represent economic grade mineralization.

METALLIC MINERAL POTENTIAL

As part of this study, geochemical results, together with the geological characteristics and previous mineral inventory results, were to be used for preparing discussions concerning metallic mineral potential. Metallic mineral potential is discussed separately for each of the ten areas in the following sections. When interpreting the geochemical data, care was taken to include the consideration of many of the processes responsible for the formation of anomalies, including lithochemistry, coprecipitation with iron and manganese, and contamination from historical mining activity. The objective is not to minimize the significance of the anomalous elemental occurrences but rather to introduce guidelines which may be used as a basis for future work.

AREA 1

1. Sand Hollow Creek - A single anomalous magnetic fraction contained .03 ppm silver. Silver potential exists in the area although it is minor at best. The lack of anomalous copper, lead, and zinc values associated with the silver significantly dilutes its potential. There is a weak possibility of disseminated silver mineralization in close proximity to vertical faults in the tuffaceous sediments. Samples of -80 mesh stream sediment are not anomalous with respect to silver.

2. Crook - One magnetic fraction sample contained .03 ppm silver, but only a minor potential exists for silver mineralization near vertical faults in tuffaceous sediments and this potential is considerably diluted by lack of associated anomalous elements. There is no correlation with the -80 mesh stream sediment data.

3. Seamon's Place - Four samples from adjacent catchment basins contained .04 to .09 ppm silver and one separate sample contained 934 ppm molybdenum (ICP). The underlying rocks (olivine basalt flows) do not have a significant potential for mineralization. However, near-vertical faults within the anomaly probably extend into tuffaceous sediments below and may have acted as a conduit for leakage and mineralization. Samples in the area contained limonitic rock fragments which may contain adsorbed silver ions. The lack of anomalous elemental associations (i.e. copper, lead, zinc) further minimizes the potential. The single sample molybdenum anomaly is of a sufficient magnitude to justify further sampling, although there is no suitable environment for porphyry molybdenum mineralization.

Mathews, et al. (1983a) assign a low favorability rating to this area for the occurrence of metallic deposits. Sub-surface information is minimal and the area is not located near any mines or mining districts. However, the report does mention a group of manganese claims located nearby in section 19, T20S, R21E.

AREA 2

4. Spring Creek - One sample collected from the Spring Creek drainage yielded .04 ppm silver, 105 ppm copper, and 1100 ppm lead. This group of elements indicates a relatively high possibility of mineralization. Andesite, basalt, and rhyolite are the main lithologies in the area, and vertical faults are located within the anomalous drainage basins. Sulfide mineralization with related silver may be associated with faults or shear zones. Samples of -80 mesh stream sediment collected by Terradata in 1982 also indicate anomalous concentrations of copper and lead.

5. Simmons Gulch - Simmons Gulch, located about four miles east of Spring Creek, yielded one sample anomalous in silver (1.1 ppm-ICP), and arsenic (130 ppm). The lithologies are similar to Spring Creek and again faulting is prominent. The potential for mineralized veins containing sulfides with related silver that are located within the fault zones is good. Samples of -80 mesh stream sediment did not show anomalous silver or arsenic concentrations.

6. Cottonwood - The Cottonwood anomaly overlies two subparallel, north-trending normal faults. One nonmagnetic sample was anomalous in silver (2.28 ppm-ICP) and three other magnetic fraction samples were anomalous in molybdenum (5-7 ppm). Rock types in the area mainly include rhyolite with minor basalt. Although the silver value is high, lack of associated chalcophile elements (Krauskopf, 1979, and Rose, Hawkes, and Webb, 1979, p. 573) reduces the potential for mineralization. The three magnetic samples with molybdenum may reflect a raised background level associated with the rhyolite and are probably not indicative of mineralization (Theobald, et al., 1967). The -80 mesh stream sediment samples collected from this anomaly were not anomalous in any elements.

Mathews, et al. (1983b) assign a low favorability rating for mercury in the area based solely on the rock types present. On the basis of available data, no other metallic minerals appear potentially favorable.

AREA 3

7. Dry Creek - Three nonmagnetic samples anomalous in silver (.03-.06 ppm) and two samples anomalous in arsenic (28-75 ppm) are found within the Dry Creek anomaly. Tuffaceous sediments of the Deer Butte Formation and basalt flows underlie most of the area. Vertical faulting is moderate throughout the anomaly. Due to the fact that the samples are only anomalous in one element and that the anomalous drainage basins are widely spaced, the potential for mineralization is poor. Samples of -80 mesh stream sediment are not anomalous in either silver or arsenic.

Mathews, et al. (1983c) give the Dry Butte area low favorability for metallic minerals although they do indicate that rocks in the area could potentially host mercury and copper mineralization. Mineral claims have been staked over optical grade calcite veins up to 25 feet thick which occur in the area. The calcite veins may be occurring above a zone of precious and base metal deposition associated with epithermal vein systems (Buchanan, 1981).

8. Dry Creek Butte - A group of nine nonmagnetic samples is anomalous in gold (7-31 ppb), silver (.06 ppm), arsenic (30-235 ppm), molybdenum (7-49 ppm), and lead (96-196 ppm). Rocks in the area consist mainly of Deer Butte Formation tuffaceous sediments broken by a set of subparallel northeast-trending vertical faults. Limonite was identified in most of the anomalous samples. The potential for mineralization in the form of precious metals in veins associated with fault zones or disseminated throughout tuffaceous sediments is moderate. Gold, arsenic, and lead were also anomalous in -80 mesh stream sediment data.

9. South Wall Rock - One nonmagnetic sample ran .02 ppm silver. Rock types include Deer Butte Formation cut by vertical faults. Lack of other anomalous elements associated with this area minimizes mineral potential. There is no anomalous silver in -80 mesh stream sediments from this area.

10. Long Gulch - Long Gulch contains 23 samples that are anomalous in gold (4 ppb), arsenic (25-145 ppm), molybdenum (2-20 ppm), lead (32- 212 ppm), fluorine (1400 ppm), tungsten (20-50 ppm), and silver (.06-.1 ppm). This area has the largest suite of anomalous elements in the study region. The Leslie Gulch Member of the Sucker Creek Formation underlies the entire area and is largely devoid of the vertical faulting associated with most of the other anomalies. Many of the samples contained minor concentrations of limonite pseudomorphs after pyrite

together with limonite cemented rock fragments. The suite of anomalous elements together with their magnitude suggests epithermal vein or disseminated mineralization, although the apparent lack of structural preparation of host rocks does not enhance the mineral potential. It may be that geologic mapping in the area has failed to notice small scale structural features or that the tuffaceous rocks are permeable enough to allow the passage of mineralizing fluids leading to the formation of stratiform disseminated deposits. However, mineral potential appears to be good within this anomaly. Arsenic, lead, and silver are also anomalous in -80 mesh stream sediment samples.

11. Red Butte - The Red Butte anomaly contains gold (12-22 ppb), silver (.06 ppm), arsenic (25-175 ppm), molybdenum (2-9 ppm), and fluorine (1100-3400 ppm). The area is underlain by Deer Butte Formation tuffaceous sedimentary rocks that are crossed by a regular spaced set of near-vertical faults. As with most anomalies in Area 3, minor concentrations of limonite pseudomorphs after pyrite were identified in the heavy mineral samples. This area has been discussed in previous reports by Gray, et al., 1983, and Robinson, et al., 1984. Red Butte itself is thought to be the preserved vent facies of a hydrothermal system. Mineralization may be similar to that found in some portions of the Rochester District, Washington (Worthington, 1981) where Tertiary lake sediments host disseminated gold perhaps introduced by hot springs solutions. Alternatively it may ressemble the Waterloo, California area (Graybeal, 1981) where disseminated silver is hosted by Tertiary volcanics. Arsenic, and to some extend gold, is anomalous in -80 mesh stream sediments. The potential for precious metals mineralization within the Red Butte anomaly appears to be good.

12. Leslie Gulch - This anomaly contains silver (.03 ppm), arsenic (25-100 ppm), molybdenum (2-18 ppm), lead (58-1080 ppm), and zinc (210-405 ppm). The area is underlain by Leslie Gulch Member tuffaceous sedimentary rocks. Geologic mapping does not show any vertical faulting, although as with Long Gulch to the north, lithologies may be permeable enough to allow the passage of mineralizing fluids. The anomalous suite of elements seems to indicate base metal mineralization with associated silver. This may be located along unmapped fault structures or in stratiform disseminated sulfide deposits. Samples of -80 mesh sediment are also anomalous in arsenic, lead, and zinc. Mineral potential in the area is good.

Gray and others, 1983, bestow a high degree of precious metals mineral potential upon all of Area 3 based upon the results obtained from -80 mesh stream sediments and soil samples, and on the favorable geology.

AREA 4

13. Hole in the Ground - The Hole in the Ground area contains anomalous gold (2-7 ppb), silver (.03-.07 ppm), arsenic (20-50 ppm), and molybdenum (2-4 ppm). With the exception of fluorine, this area contains the same suite of elements, albeit of lower magnitude, as the Red Butte anomaly located about six miles to the north. The geology is also similar with Deer Butte Formation rocks, cut by near-vertical, north-trending normal faults underlying most of the area. Discussion of the epithermal precious metals model presented by Eimon, 1981, and Berger and Eimon, 1982, indicates that in a favorable environment, pathfinder elements together with precious metals values may be of a lower magnitude if erosion of the mineralized zone has not taken place. Gold, silver, and arsenic are also anomalous in -80 mesh stream sediment samples. The mineral potential for this area appears good.

14. Lambert Rocks - Anomalous values of silver (.02 ppm), arsenic (25-40 ppm), and molybdenum (2-13 ppm) in nonmagnetic samples, together with gold (2-3 ppb), and silver (.02 ppm) in magnetic samples outline the Lambert Rocks area. Deer Butte Formation and tuffaceous lacustrine sediments with intercalated basalt and olivine basalt flows underlie the area. Geologic mapping shows the area to be devoid of the north-trending faults common to the anomalies located to the north, however, a minor east-west fault trend does dissect the locality. The possibility of disseminated gold-silver mineralization associated with fault zones exists in the area. Arsenic and molybdenum are also anomalous in -80 mesh stream sediments.

15. Owyhee Butte - This anomaly contains three magnetic fraction samples that are anomalous in silver (.03-.15 ppm). Quaternary basalt flows underlie most of the area. Although -80 mesh stream sediments are also anomalous in silver, lack of faulting and the absence of other chalcophile elements severely reduces precious metals mineral potential. It may, in fact, be that magnetite grains within the sample simply reflect a shift in the background level for silver.

16. South - Contains two magnetic fraction samples with anomalous silver values (.02-.03 ppm). The addition of tuffaceous sediments to the underlying rock units slightly elevates precious metals potential when compared to Owyhee Butte anomaly located immediately northwards, but the area probably has an elevated background level for silver which is reflected in the magnetite. The area is not anomalous for silver in -80 mesh stream sediment samples.

Gray and others, 1983, indicate that the whole of Area 4 is located within their assigned precious metals (gold) province and as such has a high degree of precious metals potential.

17. Poison Drift Fence - This area contains nonmagnetic samples with high values of gold (3-350 ppb), silver (.04 ppm), tin (25-45 ppm), and magnetic samples with anomalous gold (5 ppb), and silver (.02-.03 ppm). The rocks in the area consist of lacustrine sedimentary units and Deer Butte Formation tuffaceous sediments that are uncut by faulting. This area contains the highest gold values located in the region which, combined with the anomalous silver concentrations, increases the precious metals mineral potential. The lack of supporting pathfinder elements and mapped faults tend to mitigate against the presence of primary mineralization. The anomalous tin values are also enigmatic, but are possibly derived from detritus which originated from rhyolitic rocks located to the southeast that became incorporated into lake sediments. Samples of -80 mesh stream sediments are anomalous in gold.

18. Porcupine Reservoir - This area contains four samples which are anomalous in gold (23 ppb), silver (.02 ppm), tin (30-50 ppm), and fluorine (900-1000 ppm). The lithology includes mostly rhyolite with minor amounts of olivine basalt, basalt, and Deer Butte Formation tuffaceous sediments. Steeply dipping normal faults cross the area in a northwest-trending direction. Gold and silver values may indicate precious metals mineralization associated with fault zones, although lack of pathfinders decreases this potential. Tin and fluorine values are probably derived from rhyolitic rocks in the nearby area which may have originated in a late stage differentiated magma similar to the McDermitt caldera complex located about 30 miles to the southwest (Rytuba and Glanzman, 1979). There is a small amount of potential for tin mineralization that might be associated with veins or faults and fractures in the area. Samples of -80 mesh stream sediments are also anomalous in gold and tin. The potential for precious metals and/or tin is low.

19 Twin Springs Reservoir - This area includes one sample that was anomalous in silver (.03 ppm). The area is underlain by rhyolitic rocks that are not faulted. The lack of pathfinder associations and of favorable geology severely reduces the mineral potential. The -80 mesh stream sediment sample collected in this area is not anomalous in silver.

Gray and others (1983) indicate that Area 5 has moderate potential for precious metals although reasons given are unclear.

AREA 6

20, Sacramento Hill - This anomaly is defined by a single magnetic fraction sample with a value of .02 ppm silver. Olivine basalt is the prominent lithology in the area. One fault is located nearby and although there is a minor possibility of mineralization along the fault, lack of supporting pathfinders or associated chalcophile elements reduces mineral potential to a minimum. Samples of -80 mesh stream sediments are not anomalous.

21, Toppin Creek - The anomaly is evident in the nonmagnetic fraction for gold (3-4 ppb), silver (.03 ppm), fluorine (1250-1400 ppm), and tin (30-50 ppm), and magnetic fraction silver (.02ppm), and molybdenum (5-6 ppm). The area is underlain by a Quarternary olivine basalt flow that overlies rhyolitic rocks. Near vertical faulting is located along the creek bottom in the area. With the exception of magnetic fraction silver and molybdenum values, results in this area are very similar to those at Porcupine Reservoir about 15 miles to the north. Mineral potential is also similar being low for both precious metals and tin. Samples of -80 mesh stream sediment also have anomalous concentrations of tin.

22. Toppin Creek Resevoir - One nonmagnetic sample is anomalous in silver (.05 ppm) and a single magnetic sample is anomalous in gold (2 ppb). Olivine basalt and rhyolite underlie the area. No faults are mapped within the area. The area has minimal potential for mineralization due to a lack of favorable geology and pathfinder element associations.

23. Oregon - One nonmagnetic fraction sample contains a silver concentration of .03 ppm. Olivine basalt forms the major lithology with geologic mapping indicating that no faults dissect the area. The mineral potential is poor due to the lack of associated pathfinder elements and the unfavorable geology; however, -80 mesh stream sediments also show anomalous concentrations of silver, probably indicating an elevated background level associated with basalt.

24. Little Owyhee Canyon - Above threshold concentrations of six elements (gold (5-6 ppb), silver (.03-.05 ppm), molybdenum (2 ppm), lead (565 ppm), fluorine (900-910 ppm), and tin (25 ppm)) define this anomaly. Rhyolite, olivine basalt, and basalt compose the lithologies with no faults having been mapped within the anomaly. Hematite, limonitic rocks, and amphibole were present in variably minor amounts within the samples. The association of the siderophile elements gold, molybdenum, lead, and tin probably represent late-stage differentiation of the magmatic source rocks for the rhyolite. Silver values may be associated with mafic constituents (amphibole) or cations coprecipitated with iron in the limonitic rocks. Mineral potential exists in the area for sulfide (lead-zinc) veins with associated precious metals and possibly cassiterite, although the potential for both is severely minimized by the low geochemical values and the lack of structural preparation in the area. Lead and tin are also anomalous in -80 mesh stream sediments.

25. Antelope - One sample with anomalous concentrations of silver (.09 ppm) defines this anomaly which is located in basaltic rocks of the Deer Butte Formation and rhyolite. Limonite cemented rock fragments were identified in the sample. The lack of associated pathfinder elements together with the unfavorable geology minimizes the mineral potential. The area is not anomalous for silver in -80 mesh stream sediments.

26. Creek - This area has anomalous concentrations of silver (.03-.04 ppm), molybdenum (2-5 ppm), zinc (202-303 ppm), and tungsten (18 ppm) in nonmagnetic fraction samples and silver (.02-.03 ppm) in magnetic fraction samples. Mafic rocks consisting of andesite and basalt overlain by silicic rocks composed of ash-flow tuff, rhyolite, and dacite underlie the area. The area is cut by a set of normal faults striking approximately northeast that are about three miles apart. Limonite cemented rock fragments, amphibole, and minor limonite were indentified in the samples. The mineral potential for zinc sulfides with associated silver occurring in veins associated with the fault zones is relatively good. Tungsten and molybdenum values are probably associated with magmatic differentiation of the silicic rocks and the mineral potential for deposits containing these elements is low. Silver and tin are also anomalous in -80 mesh stream sediments.

27. West Trout - The area is outlined by anomalous gold (10-12 ppb), silver (.02-.05 ppm), molybdenum (2-3 ppm), and tungsten (16-40 ppm) in nonmagnetic fraction samples and silver (.02-.14 ppm) in magnetic fraction samples. Small outcrops of andesite and basalt overlain by large amounts of silicic rocks including ash-flow tuff, rhyolite, and dacite underlie the locality. The area is cut by a few north-trending normal faults and a synformal structure that has its axis crossing the western portion of the area in a northern direction. Limonite cemented rock fragments, amphibole, and hematite were identified in variable quantities in all of the anomalous samples. Estimating mineral potential for gold and silver is difficult because of a lack of good pathfinder association. The molybdenum and tungsten potential is low. Values in these elements are probably caused by late-stage differentiation of source rocks for the rhyolite, dacite, and/or ash-flow tuff, the explanation given for similar anomalies located in the southeastern portion of the study region. Silver and gold are also anomalous in -80 mesh stream sediments.

28. Opalite Reservoir - The Opalite Reservoir area is anomalous in nonmagnetic fraction gold (7 ppb), silver (.03-.05), molybdenum (2-4 ppm), and tin (25-30 ppm), and magnetic fraction gold (3 ppb) and silver (.02 ppm). This anomaly is underlain by a similar sequence of rocks (andesite, basalt, ash-flow tuff, rhyolite, and dacite) that underlies other anomalies located in Area 7. However, the rocks are broken by faulting associated with the ring fault zone of the McDermitt caldera complex located immediately to the south. Limonite cemented rock fragments and minor limonite were identified sporadically in the anomalous samples. Due to the favorable structural setting and the location near economic grade mercury and uraniumn mineralization (Rytuba, 1981), potential for precious metals occurrences is moderate. The lack of a pathfinder association makes the prediction of mineralization types difficult. Molybdenum and tin values are probably due to late-stage differentiation of the magmatic source rocks for the silicic assemblage occurring in the area and mineral potential for deposits containing significant quantities of these elements is negligible. Gold, silver, and tin are also anomalous in -80 mesh stream sediments.

29. Trout SW - Four magnetic fraction samples contained concentrations of silver ranging from .02 to .12 ppm. Rocks in the area consist of basalt, andesite, ash-flow tuff, rhyolite, and dacite that are cut by fault sets trending north-south and east-west. The mineral potential is good based on the number of anomalous samples and their magnitude. Possible mineralization types are enigmatic due to the lack of pathfinder or chalcophile element associations. Silver is also anomalous in -80 mesh stream sediments.

Weissenborn (1969) discusses the Opalite and Bretz mercury mines located in the ring fracture zone in the southeastern end of Area 7 and Gray and others (1983) indicate that located immediately south of the area is a large drilled-out uranium deposit. They (Gray and others, 1983) say the area has good potential for gold with mercury mineralization, however mercury was not determined in the heavy mineral program.

30 Pueblos NW - The area contains nonmagnetic fraction samples with above threshold values for silver (.04 ppm), arsenic (20-30 ppm), and copper (65-69 ppm), and magnetic fraction samples with anomalous silver values (.02-.04 ppm). Steens basalt underlies the majority of the area along with small amounts of tuffaceous rocks. Generally, the samples contained minor amounts of limonite cemented rock fragments and limonite pseudomorphs after pyrite, a suite similar to the one found in most arsenic anomalies in Area 3. It is probable that arsenic was coprecipitated with iron leading to anomalous concentrations in stream sediments. Silver and copper values may be attributed to an increase in the background associated with the Steens basalt. For these reasons, and including the lack of other silver indicator elements (lead or zinc), the mineral potential in the anomaly is rated at moderate to poor. Copper is anomalous in -80 mesh stream sediments.

31. Pueblos SW - The area is anomalous in nonmagnetic fraction gold (30 ppb), silver (.05-.07 ppm), and copper (69-129 ppm), and magnetic fraction silver (.02-.11 ppm), and copper (105-139 ppm). Steens basalt and lacustrine tuffaceous sedimentary rocks underlie the area. Two sets of normal faults cut the area and approximately parallel the range front fault that forms the scarp on the eastern side of the Pueblos. Silver and copper results in both magnetic and nonmagnetic samples are probably attributable to elevated background levels in the Steens basalt. The sample with anomalous gold contained no unusual minerals and the lack of pathfinder elements makes mineral potential difficult to reasonably estimate. Copper values are also anomalous in -80 mesh stream sediments.

32. Pueblos E - Nonmagnetic fraction gold (4 ppb), silver (.04-.06 ppm), copper (70-560 ppm), molybdenum (24 ppm), and tungsten (32-40 ppm) together with magnetic fraction silver (.05 ppm) define this anomaly. The area is underlain by a small plug of pre-Tertiary Jurassic-Cretaceous granitic rocks in the south that intrude metamorphosed Permo-Triassic sedimentary rocks, along with Tertiary Pike Creek Formation tuffaceous sediments and Steens basalt. Minor numbers of normal faults that subparallel the range front fault on the east side of the Pueblos dissect the area. It is of interest to note that, in the mineral identification portion of program, almost all anomalous nonmagnetic fraction samples contained limonite pseudomorphs after pyrite. Copper and silver values again can be attributed to elevated background levels of the Steens basalt, although one sample did reach 560 ppm which is well above the normal background for a basalt. The molybdenum and tungsten values are probably attributable to late-stage differentiation of the magmatic rocks that were the source of the tuffaceous sediments. The mineral potential is moderate for disseminated precious metals deposits. Gold and copper are also anomalous in -80 mesh stream sediments.

Gray and others (1983, Table 13.) list the mines and prospects located within the eastern Pueblo Mountains. Mineralization generally consists of cinnabar, copper minerals, and minor gold occurring with a gangue of quartz, calcite, and limonite in small veins usually hosted by metasedimentary and metavolcanic rocks. They (Gray and others, 1983) indicate that the eastern portion of the area has a potential for epithermal gold and copper-molybdenum porphyry systems.

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33. Tencent Lake - This area contains two nonmagnetic fraction samples that are anomalous in arsenic (35 ppm), copper (120-145 ppm), molybdenum (202 ppm), and lead (90 ppm). Lithologies include lacustrine tuffaceous sediments, andesite, and basalt. There are two northwest-trending normal faults three to four miles in length in the area. Limonite cemented rock fragments were identified in the samples. The sample sites in this area are widely separated, hence the anomaly is not very well defined. However, the anomalous suite of elements together with favorable geology indicate a good degree of mineral potential for the anomaly. Mineralization would probably be sulfides with a quartz gangue filling veins associated with faulting. Lead is also anomalous in -80 mesh stream sediment samples (Terradata).

34. Table Mountain West - One sample is anomalous in copper (108 ppm). The area is underlain by andesite and basalt cut by northwest-trending normal faults. The lack of associated anomalous chalcophile elements precludes the possibility for base-metal mineralization and enhances the likelihood that the copper is associated with the mafic rock types. Mineral potential for this area is poor. Copper is also anomalous in -80 mesh stream sediments.

35. Mickey Cabin - Silver is anomalous in three nonmagnetic and magnetic samples (.05-1.9 (ICP) ppm) and copper is above threshold in two nonmagnetic samples (111-153 ppm). Andesite and basalt, together with a small amount of tuffaceous sedimentary rocks underlie the area. Two sets of near vertical normal faults that trend northwest and northeast dissect the area. These faults are apparently associated with the Brothers fault zone. Generally the copper and silver values can be attributed to mafic rocks with elevated backgrounds, however, the 1.9 ppm silver is of a magnitude that suggests moderate mineral potential. The lack of associated pathfinders or chalcophile elements reduces the potential and makes estimating mineralization types difficult. Copper is also anomalous in -80 mesh stream sediments.

36 Ancient Lake - This area is defined by one nonmagnetic sample that has a silver concentration of .59 ppm (ICP) and another sample having a zinc value of 879 ppm. Welded tuff, rhyolite, and dacite underlie the area. Normal faults striking approximately northeast occur in the area. The relatively high values of silver and zinc may indicate sulfides with associated silver veins occurring in fault zones. This area is located about five miles north of the Creek anomaly in Area 7 which also contains high silver and zinc values and the mineral potential is, again, relatively good. Silver is also anomalous in -80 mesh stream sediments.

Mathews and Blackburn (1983b) state that the volcanogenic environments in Area 9 are favorable for the occurrence of metallic deposits with an emphasis placed on mercury, however, no direct evidence exists. Also, the Mickey Hot Spring area located in the western portion of Area 9 contains surface manifestation of hot springs activity and may be classified as a geothermal deposit.

AREA 10

37. Well - The Well anomaly has three samples anomalous in gold (8ppb) and silver (.02-.03 ppm). Rocks in the area consist of Steens basalt cut by northeast-trending faults that are part of the Brothers fault zone. The silver values are all from magnetic fraction samples and probably represent trace concentrations of silver in magnetite rather than mineralization. The gold anomaly is difficult to interpret due to a lack of pathfinder elements. Here, the mineral potential is poor to moderate. Silver and gold are also anomalous in -80 mesh stream sediments.

38 Donner - The Donner area contains six nonmagnetic samples with anomalous concentrations of silver (.04-.09 ppm). The anomaly is underlain wholly by Steens basalt cut by normal faults associated with the Brothers fault zone. Limonite cemented rock fragments were commonly identified in the samples forming the anomaly and as a result, the high concentrations of silver are most likely attributable to silver being coprecipitated with iron oxides. The silver probably originates from the mafic rocks and not mineralization. Mineral potential is poor for the area. Silver is not anomalous in -80 mesh stream sediments.

39. Blitzen - This anomaly is defined by four nonmagnetic samples with high concentrations of silver (.02-.08 ppm) and tungsten (18-100 ppm). The area is underlain by Steens basalt along with a small amount of tuffaceous sediments, both of which are dissected by faults associated with the Brothers fault zone. Limonite cemented rock fragments were commonly identified within anomalous samples most likely indicating that, as with the Donner area to the north, silver concentrations are caused by coprecipitation with iron oxides and not to mineralization. Tungsten values may be due to late-stage differentiation of the source rocks for the tuffaceous units, hence mineral potential for this commodity is slightly better. Silver and tungsten are not anomalous in -80 mesh stream sediments.

40. Central Steens - The Central Steens anomaly is easily the largest in the study region covering over 50 square miles located in the center of Area 10. Fifty-seven samples are anomalous in copper (69-110 ppm) and three samples in silver (.02-.03 ppm). The area is underlain in its entirety by Steens basalt cut by normal faults associated with the Brothers fault zone. The copper concentrations are uniform and are undoubtedly attributable to the mafic lithologies rather than mineralization. Rose, Hawkes, and Webb (1979, pg. 555) list 72 ppm as the average copper concentrations of mafic rocks.

Silver values are probably associated with limonitic rock fragments as are the Donner and Blitzen anomalies located immediately to the west. Mineral potential for this area is poor. Copper is also anomalous in -80 mesh stream sediments.

41. North Steens - This area contains four nonmagnetic fraction samples with anomalous silver concentrations (.02-.12 ppm) and four magnetic fraction samples with anomalous gold concentrations. For the most part, Steens basalt underlies the area together with a minor amount of Pike Creek Formation tuffaceous sedimentary rocks cut by normal faults striking north-northeast that parallel the fault scarp located on the eastern side of Steens Mountain. The Steens basalt probably contains elevated background amounts of silver as indicated by anomalies to the west. However, Pike Creek Formation rocks appear to be highly anomalous four to six miles to the south and, therefore, this anomaly has a moderate mineral potential associated with the tuffaceous sedimentary rocks. Gold and silver are not anomalous in -80 mesh stream sediments.

42. Steens SE - The Steens SE area contains nine samples containing arsenic (20-230 ppm), molybdenum (2-35 ppm), lead (44-72 ppm), and tungsten (17-100 ppm) in nonmagnetic fractions, and gold (4 ppb), silver (.03 ppm), and copper (107-176 ppm) in magnetic fractions. The anomaly is underlain by equal portions of Steens basalt and Pike Creek Formation tuffaceous sedimentary rocks that are cut by two sets of normal faults. One set is approximately parallel to the range front fault located along the eastern Steens mountain, and the other approximately parallels the Brothers fault zone. This anomalous suite of elements in part may indicate magmatic differentiation of source rocks for the tuffaceous unit (Mo, W), and elevated background levels in the Steens basalt (Ag, Cu), but the addition of relatively high arsenic and lead values increases the potential for mineralization dramatically. A good potential exists for occurrences of both disseminated precious

metals in tuffaceous sediments and sulfide veins associated with faulting. Arsenic, lead, copper, and molybdenum are also anomalous in -80 mesh stream sediments.

Gray, et al. (1983, Table 15) summarize data from prospects and occurrences located on the eastern side of Steens Mountain. Mineralization consists mainly of mercury and uranium minerals with minor amounts of silver and manganese occurring in quartz and calcite veins hosted by rhyolitic and tuffaceous rocks. They state that not only does the eastern portion of the area have a good uranium and mercury potential due to historical mining activity, but that it also contains requirements to fit the epithermal gold model.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Several authors (Buchanan (1981), Graybeal (1981), Bonham and Giles (1983), Worthington (1981), Eimon (1981), and Berger and Eimon (1982)) have studied characteristics of both precious metals occurrences in volcanic environments and hot springs precious metals deposits. Results from these studies and others indicate that in order for mineralization to take place, various conditions must be met. These conditions include but are not limited to: Tertiary calc-alkaline extrusions with hypabyssal intrusions; fractures associated with a caldera environment; large volumes of argillic to propylitically altered rocks; high permeability zones which have resulted from tectonic shattering, either from orogenic stress, volcanic activity, hydrothermal alteration, or leaching; vertical faulting; an extensional environment; high heat flow, mixed hydrothermal solutions originating from both magmatic and meteoric waters; and a near surface, low temperature environment related to a geothermal cell. Various models have been derived that contain some or all of these characteristics. White and Heropoulos (1983) and White (1981) have studied active hydrothermal systems to relate present to fossil hydrothermal systems.

Depending upon how much erosion of the mineralizing system has taken place, mineral assemblages and alteration patterns may vary from agate and clay near the paleosurface, through barren calcite veins, to quartz, calcite, adularia, and precious metals, and finally to quartz, adularia, and base metals (Buchanan, 1981). These systems are apparently not time-dependent, and hence may occur throughout geologic history (Eimon, 1981).

CONCLUSIONS

Previous workers (Buchanan (1980), Crerar et al (1981), Bonnie and Orville (1982), Worthington (1983), Dixon (1986), and Barnes and Ellmen (1988)) have studied characteristics of both precious metals concentrations in volcanic environments and hot springs precious metals deposits. Besides from these studies and others indicate that is occur for mineralization to take place, various conditions must be met. These conditions include but are not limited to: Tertiary calc-alkaline extrusions with hypabyssal intrusions; fractures associated with a caldera environment; large volumes of argillic to propylitically altered rocks; high permeability zones which have resulted from tectonic shattering, either from orogenic stress, volcanic activity, hydrothermal alteration, or faulting; vertical faulting; an extensional environment; high heat flow; mixed hydrothermal solutions originating from both magmatic and meteoric waters; and a near surface, low temperature environment related to a geothermal cell. Various models have been derived that contain some or all of these characteristics. White and Bergquits (1963) and White (1981) have studied active hydrothermal systems to relate present to fossil hydrothermal systems.

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Statistical treatment of the results obtained from the geochemical analysis of over 1,800 heavy mineral concentrate samples have helped to identify 42 anomalies located in Wilderness Study Areas in Southeastern Oregon. The anomalies vary in size and magnitude, and contain anomalous element suites ranging from one element to up to six elements. They are located in geologic environments which range from a very low to a very high favorability in terms of the epithermal model characteristics described above. The Red Butte anomaly is in an area of brecciation and siliceous alteration associated with the preserved vent facies of a hydrothermal system (Dr. Mike Cummings, Portland State University, 1984, Robinson, 1984).

Anomalies at Opalite Reservoir, Pueblos E, and Steens SE are located in areas of historical mining activity, mainly for mercury and uranium (Gray et al., 1983). Other anomalies (i.e. Long Gulch, Leslie Gulch, and Little Owyhee Canyon) have anomalous elemental patterns, but with no historical mining activity.

Limonite cemented rock fragments were identified in quantities that ranged from a trace to very common in samples from nearly every anomaly. Limonite pseudomorphs after pyrite (generally rare throughout the entire survey area) were identified in variably minor amounts in samples from the major gold, silver, and arsenic anomalies. Other interesting mineral identification associations noted were garnets in samples collected from tuffaceous sediments (presumably from igneous or metamorphic clasts incorporated in the sediments) and amphiboles, apparently from rhyolitic rock, identified in the majority of the samples that were anomalous in only silver.

When comparing anomalies (Tables 6-15) in heavy mineral concentrate data to anomalies in -80 mesh stream sediment data it was found that gold, arsenic, copper, lead, zinc, and tin had high correlation; silver had moderate correlation; and tungsten and molybdenum had no correlation.

RECOMMENDATIONS

Several anomalies located in southeastern Oregon contain element associations and favorable geology that warrant further investigation. Table 15 lists the anomalies which were identified as having a high potential in the Mineral Potential section of this report.

Table 15.
Anomalies With High Mineral Potential

Spring Creek	Creek
Simmons Gulch	Opalite Reservoir
Tencent Lake	Trout SW
Ancient Lake	Pueblos E
Long Gulch	Steens SE
Red Butte	Leslie Gulch
Hole in the Ground	

Spring Creek, Simmons Gulch, Tencent Lake, and Ancient Lake are located in areas that were sampled during the Terradata program. The sampling in this program was reconnaissance in nature, hence detailed definition of anomalies is lacking. For these areas, a program of detailed stream sediment sampling is recommended. Samples collected at 500 feet intervals along major drainages and from the mouths of side drainages would define respective anomaly sizes and locations with improved accuracy.

The remaining anomalies are located in areas sampled during the DOGAMI program and, in some areas, was more detailed. Recommended follow-up programs for these anomalies include detailed stream sediment sampling, again with a 500 ft. spacing, or where the anomalies have better definition, residual soil sampling is required. Due to the steep and rugged nature of the terrain in southeastern Oregon, a sampling

program that conforms to topography is highly desirable. Sample traverses that follow the crests and spurs of ridges should be implemented (Rose, Hawkes, and Webb, 1979). The sampling interval should be small enough (100 feet) so that at least two, if not more, adjacent samples are anomalous. Detailed geologic mapping should proceed simultaneously with soil sampling to delineate any surface manifestations (alteration, silicification, etc.) of epithermal mineralization. Geochemical analysis of soil samples should include gold, silver, arsenic, and mercury to identify mineralization and copper, lead, and zinc to help discriminate mineralization types.

The limonitic rock fragments and more specifically limonite pseudomorphs after pyrite described above are apparently associated with many anomalies. It is well known that many elements can be coprecipitated with iron, resulting in a useful mineralization guide (Rose, Hawkes, and Webb (1979, p. 559), Dyck (1971), Nowlan (1976), and Chao and Theobald (1976)). However, the close association between limonite and some of the stronger precious metals anomalies deserves further study. Limonite pseudomorphs after pyrite could contain trace concentrations of the anomalous metals, and if so, work should proceed so as to determine whether pyrites are syngenetic, diagentic, or epigenetic, and if they in fact are a useful guide to mineralization in the southeastern Oregon area. Similarly, future stream sediment programs should include iron and manganese determinations in the analytical suite. Regression equations utilizing these two elements can be formulated to predict various precious metal and pathfinder values. The difference between predicted values and actual values can help determine whether an area is either truly anomalous of if the anomalies are simply due to excess precipitation of iron and manganese, which have served to scavenge anomalous concentrations of other ions by coprecipitation and adsorption (Larsson (1976), Rose and Suhr (1971), Rose et al. (1970)).

As part of this program, the results obtained from previous -80 mesh stream sediment studies were to be utilized during the interpretation of the heavy mineral concentrate anomalies. The anomaly maps produced as a part of the DOGAMI study were very difficult to use due to the low threshold values picked for most elements, the grouping together of four to six elements per map, and the lack of posted raw data values. It is recommended that -80 mesh data be further processed and single element anomaly maps with posted values be plotted for each area. It was also noticed that a few of the heavy mineral anomalies did not correlate with -80 mesh data. For this reason, if the samples exist, reanalysis for the non-correlative elements is recommended.

There have been numerous problems in this project that have resulted from the very limited and variable quantities of many of the samples. These difficulties have dramatically affected both the analytical program and have markedly decreased the breadth of the conclusions and recommendations. Panning in the field is a notoriously unreliable method of preparing heavy mineral concentrate (Mertie (1954), Theobald (1957)). Fine-grained and platy heavy minerals are very easily lost from the samples and the retention of the coarser fractions may be highly variable. These problems become extreme where dry-panning is practiced. It is therefore highly recommended that heavy mineral concentrates should never be collected by panning in the field. Although the collection of adequate volumes of sediment (10 lb+) may lead to logistical problems during the sampling program, heavy mineral concentration should only be performed in a laboratory where strict control of the method is possible.

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